Optimum Scheduling of Combined Hydroelectric and Wind Generation

CEA 2004

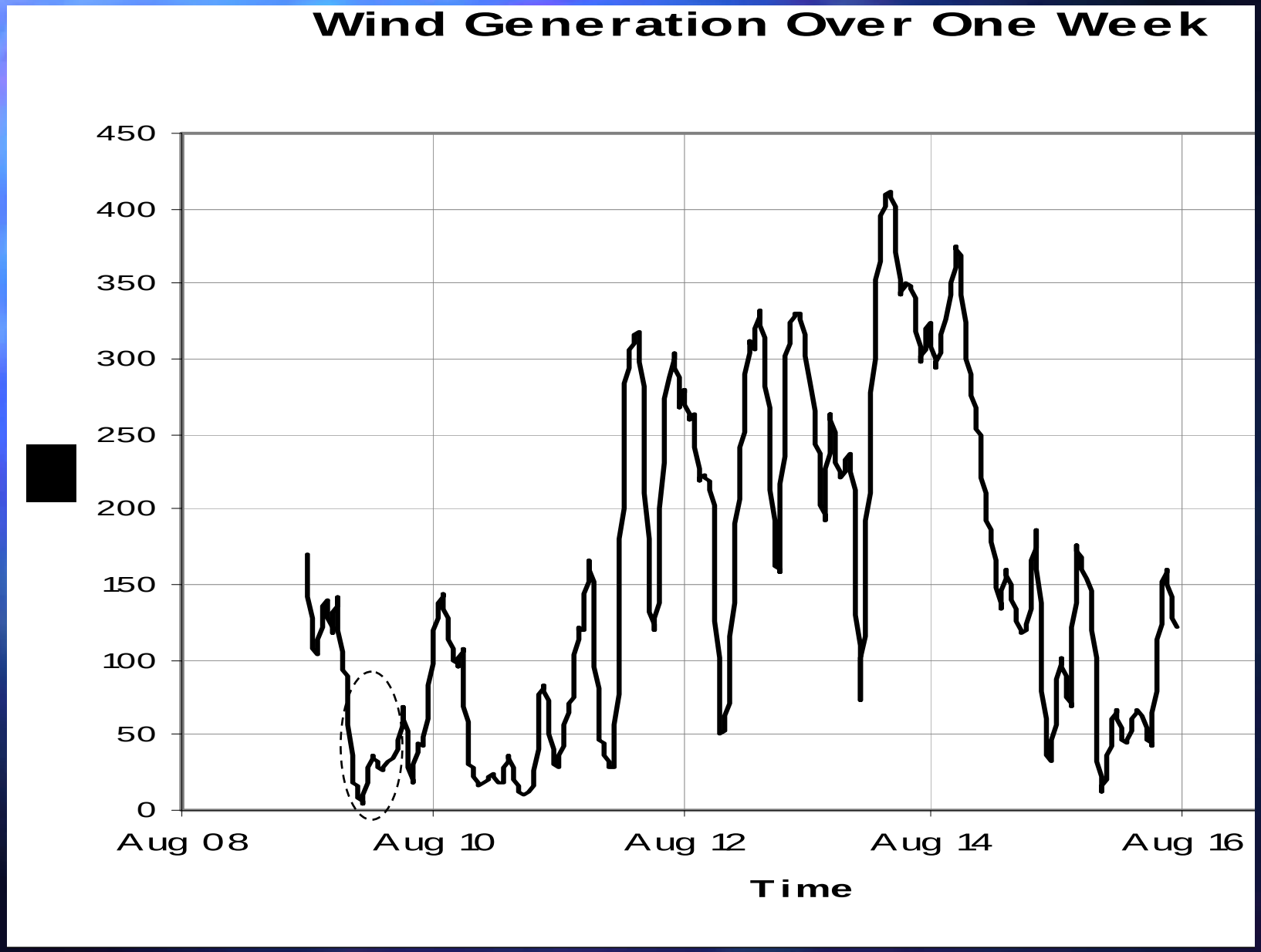
SYNEXUS GLOBAL
An Acres Company
Une filiale d'Acres

Redefining Asset Management

Presentation Outline

- Wind Generation Issues
- Objectives of Analysis
- Methodology
  - Hydro operations (ST Vista, AUTO Vista)
  - Modifications for wind generation
- Preview of Interaction Effects

Wind Generation Issues - I



Wind Generation Issues -- II

- High variation in short-term power output
  - Requires regulation
  - Requires higher reserves
- Hydro can regulate and provide compensating reserves – at a cost
  - Reduced efficiency
  - Increased spill

Objectives

- Quantify Impacts on Hydro Operations
  - Efficiency loss
  - Lost market opportunities
  - Spill Increase
  - Associated Revenue Impacts
- Determine Saturation Point ("How many Wind MW can we economically absorb?"

Methodology for Hydro-Wind Integration

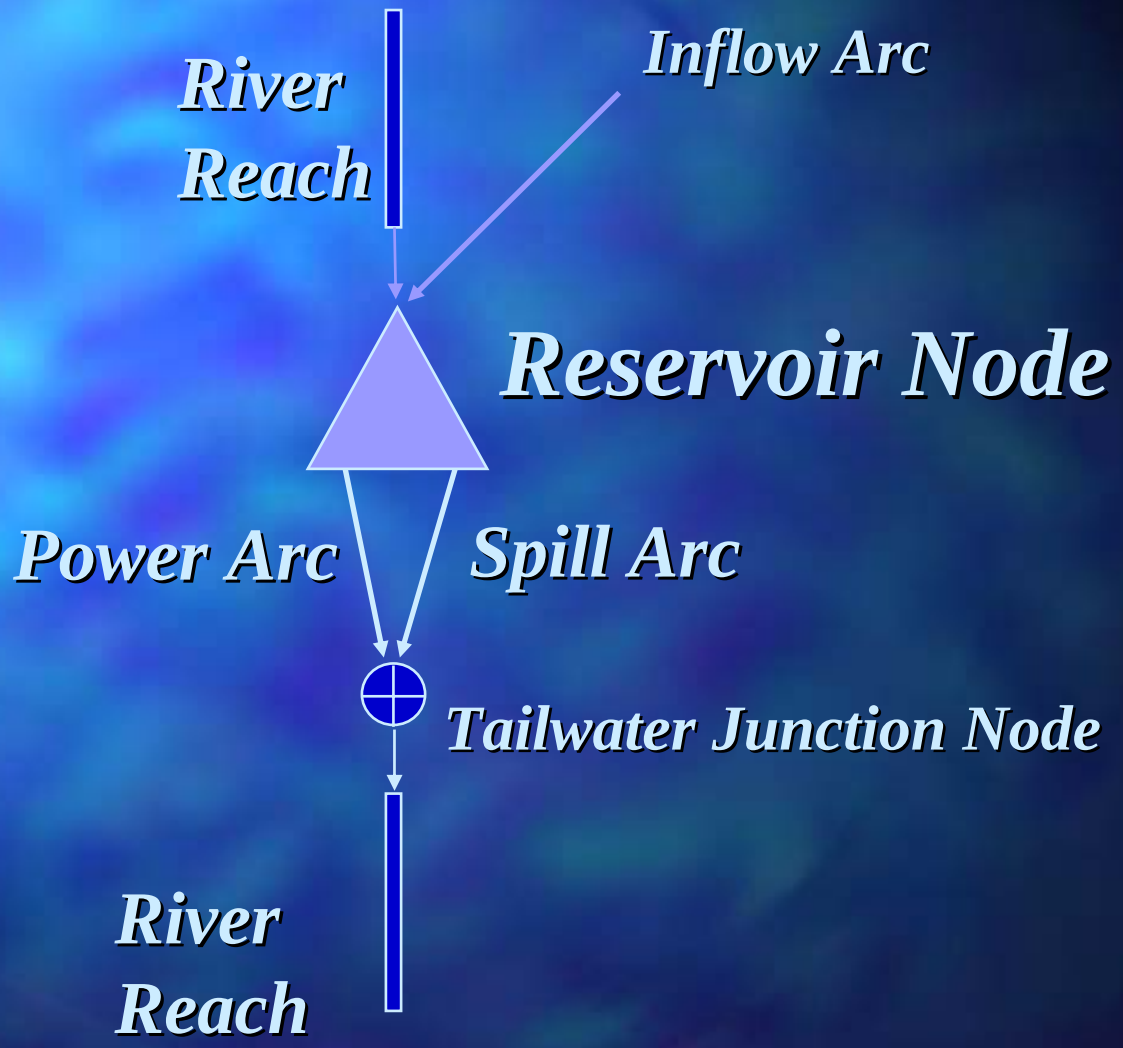
Model Operations as follows:

1. **Establish a “status Quo” operation (pre-wind generation implementation”)**
2. **Add wind generation inputs**
3. **Re-assess hourly hydro operations**

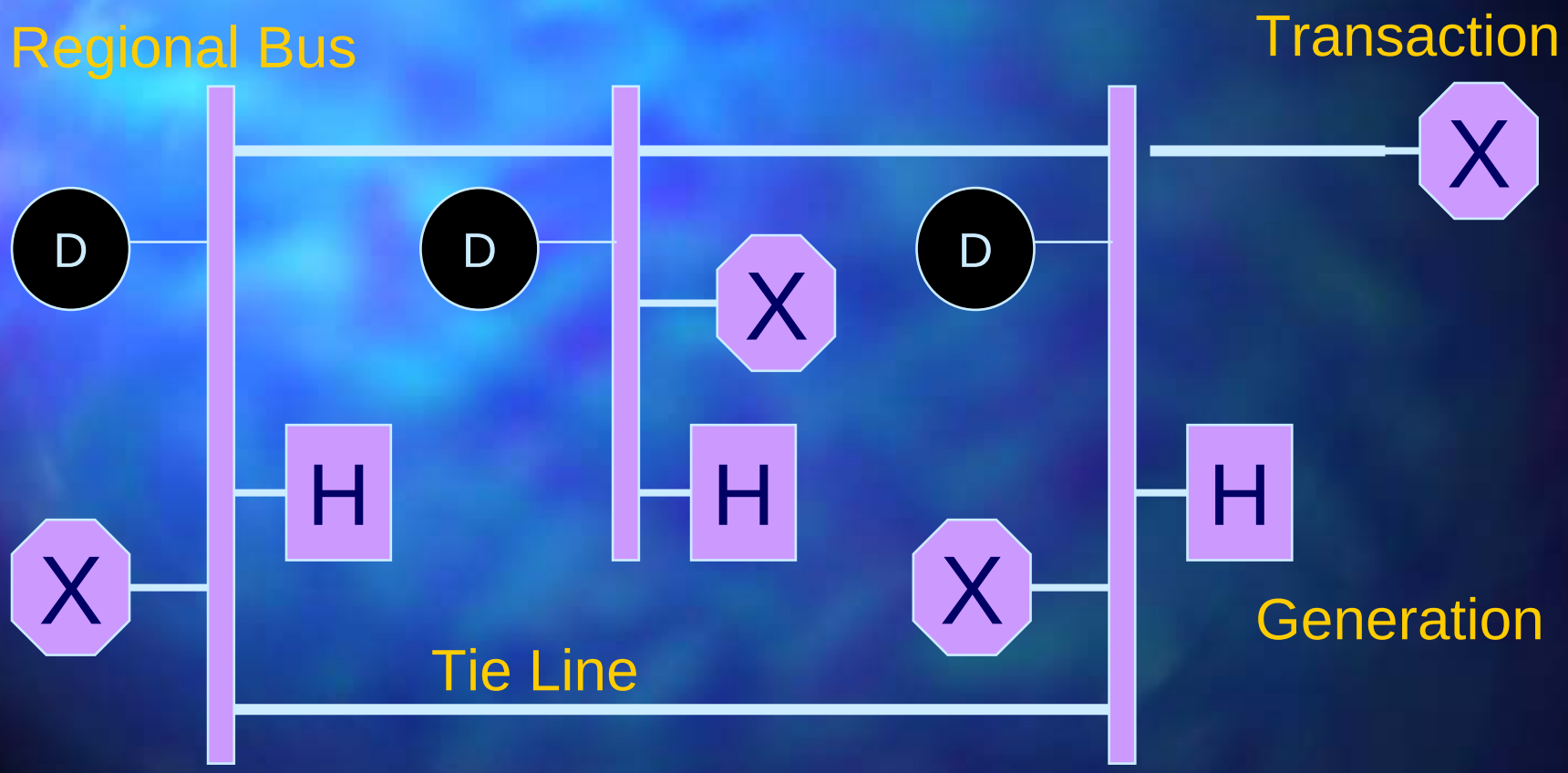
Pre-Wind Implementation

Review of ST Vista

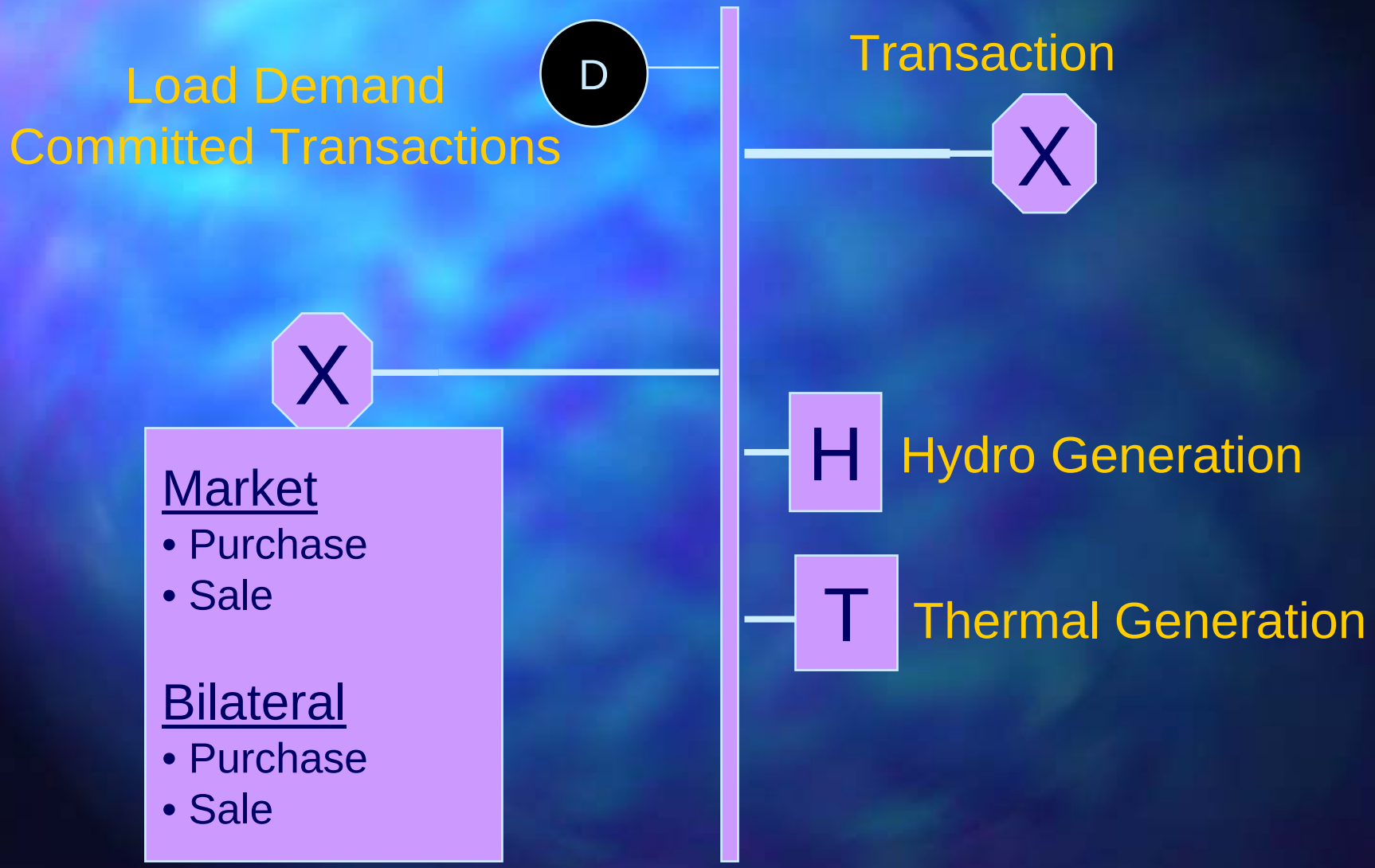
Hydro System Components



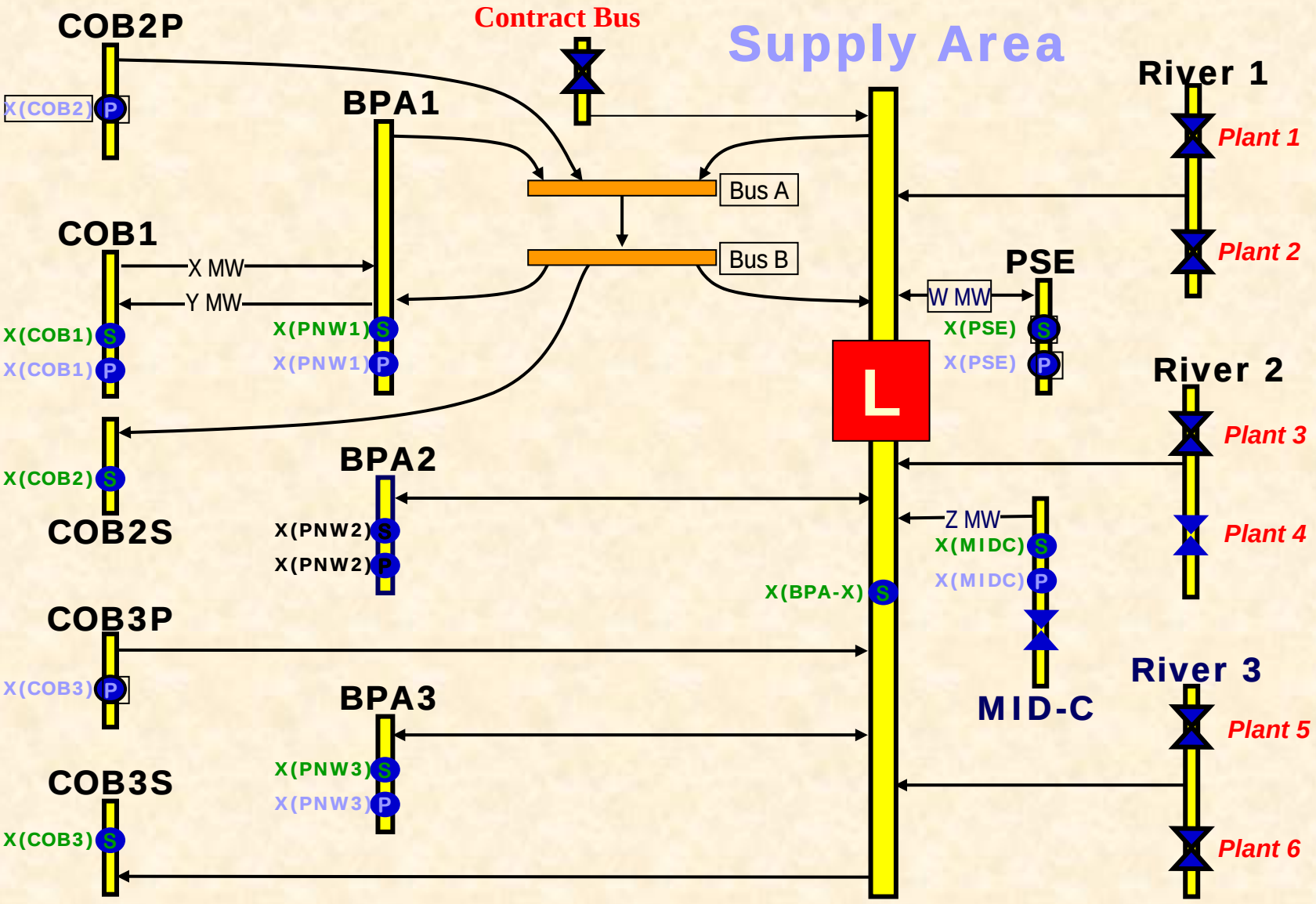
Transmission System Components



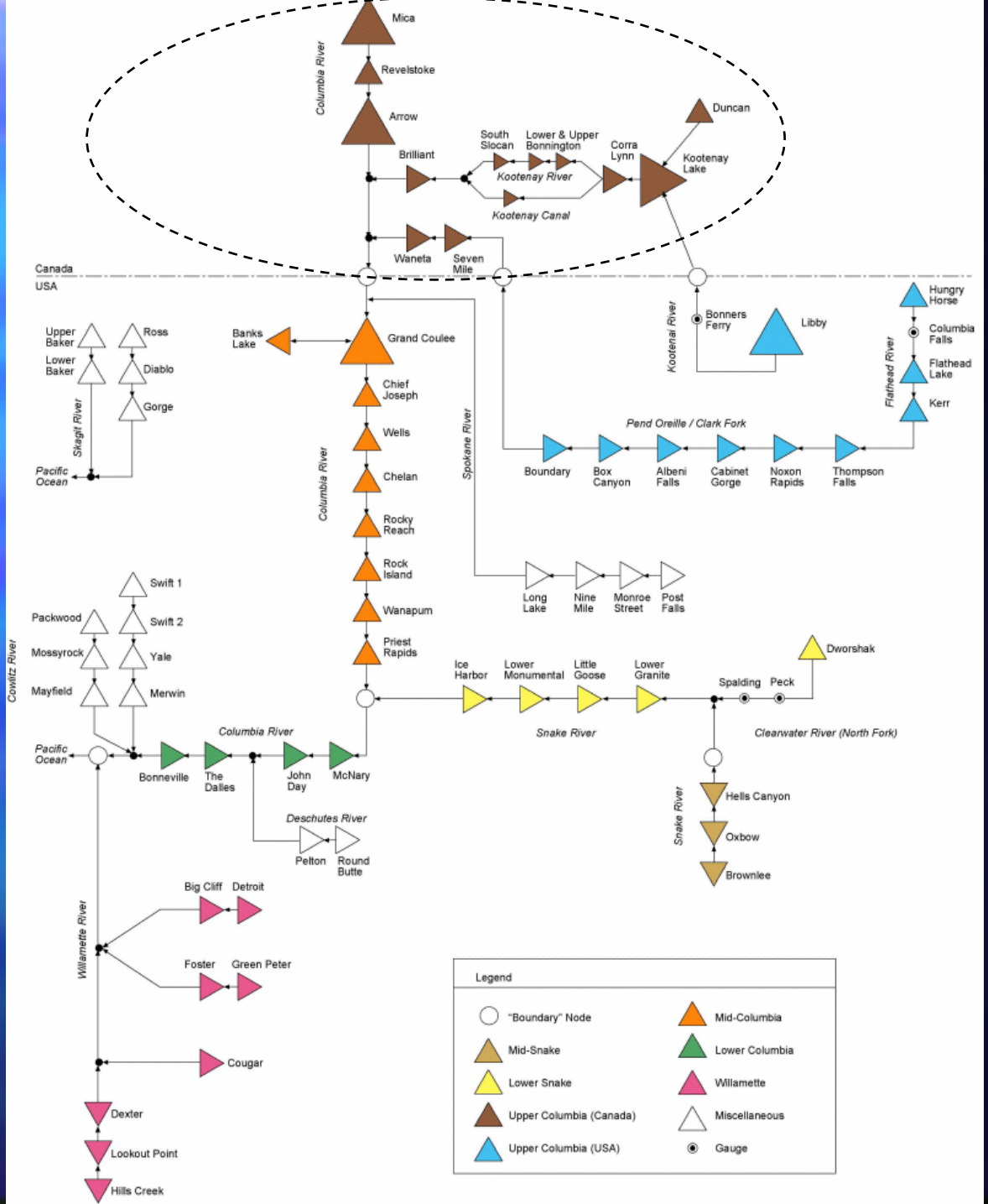
Transmission Area



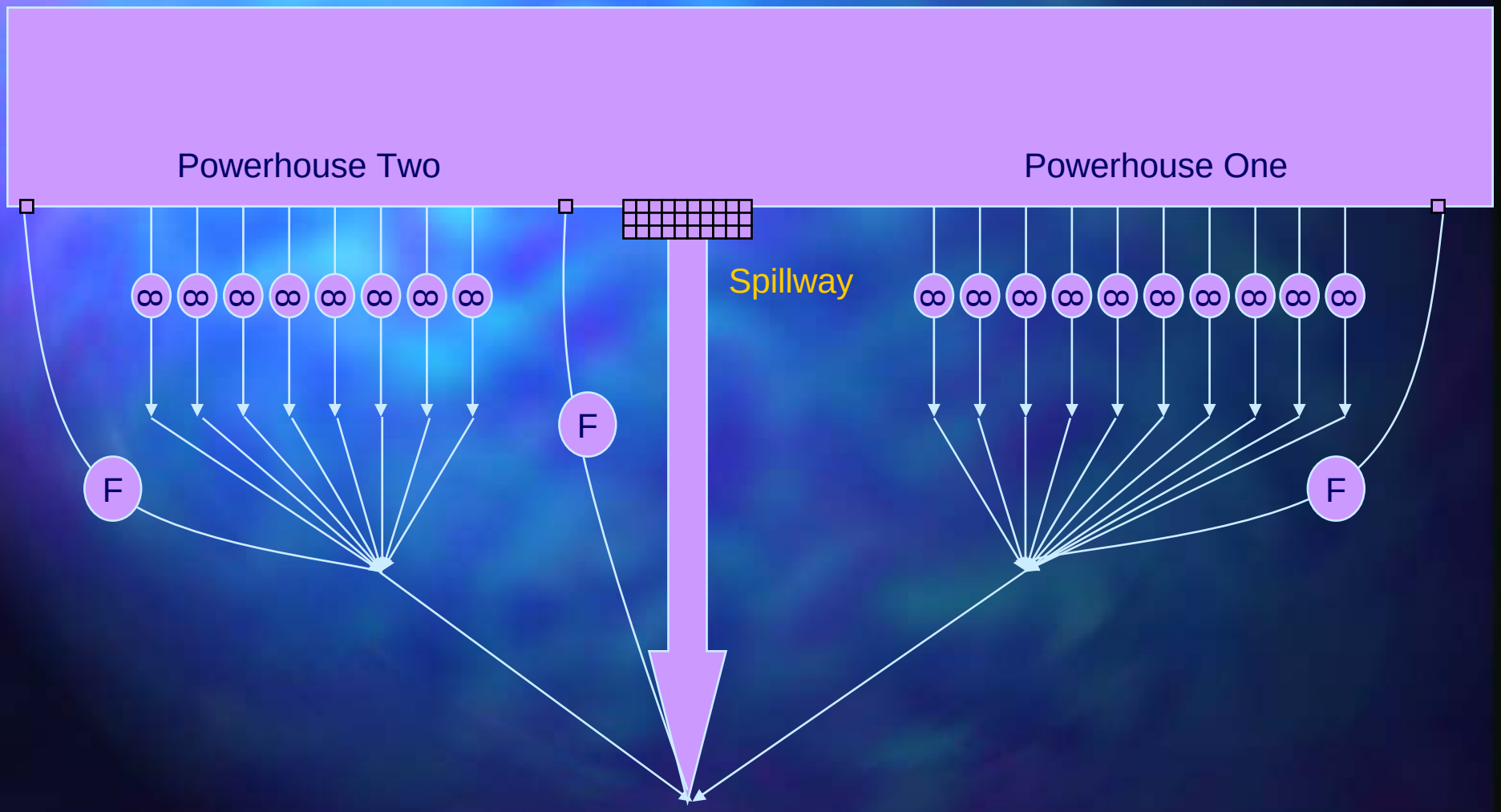
Bus Configuration

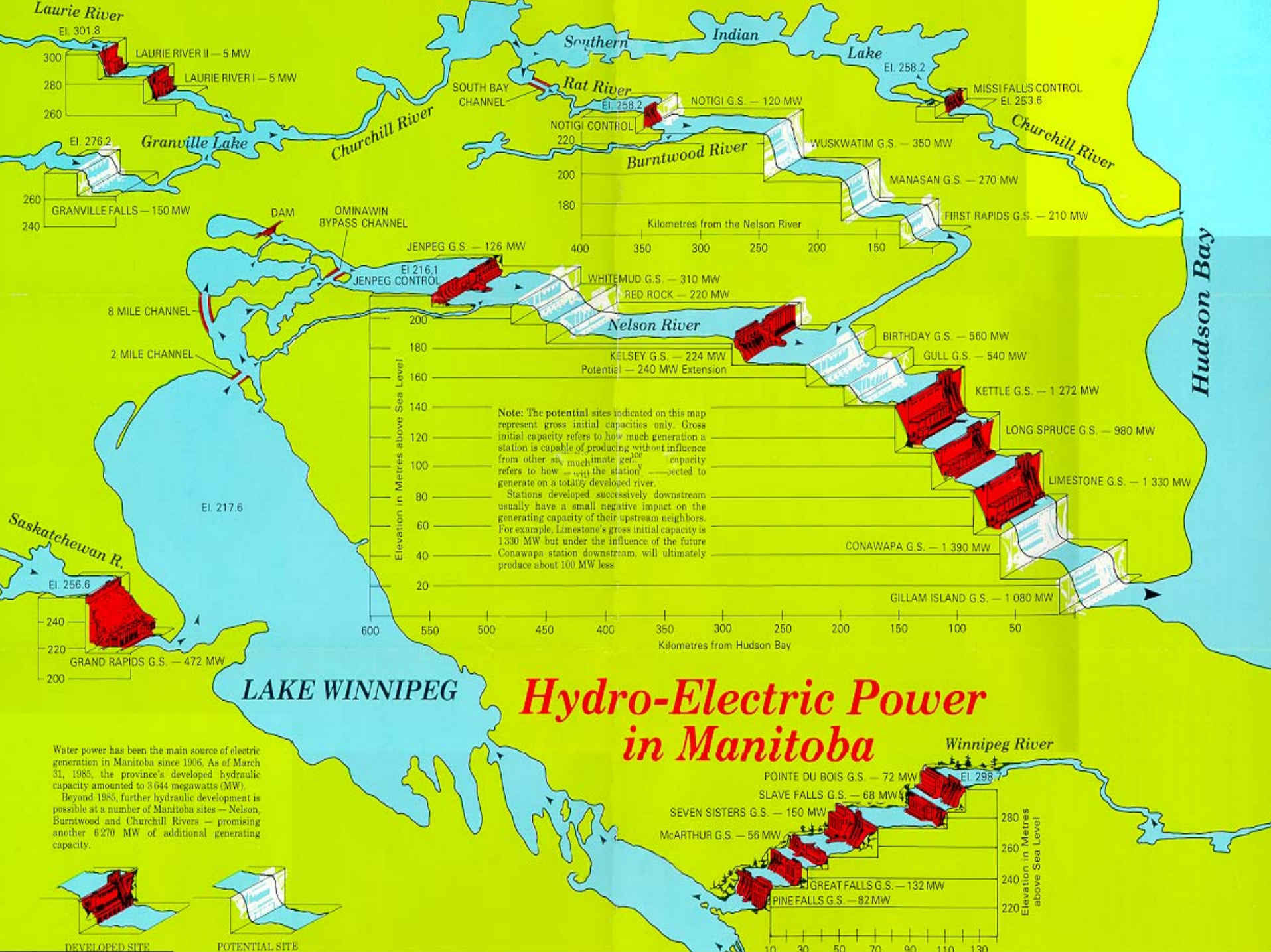


Columbia River System



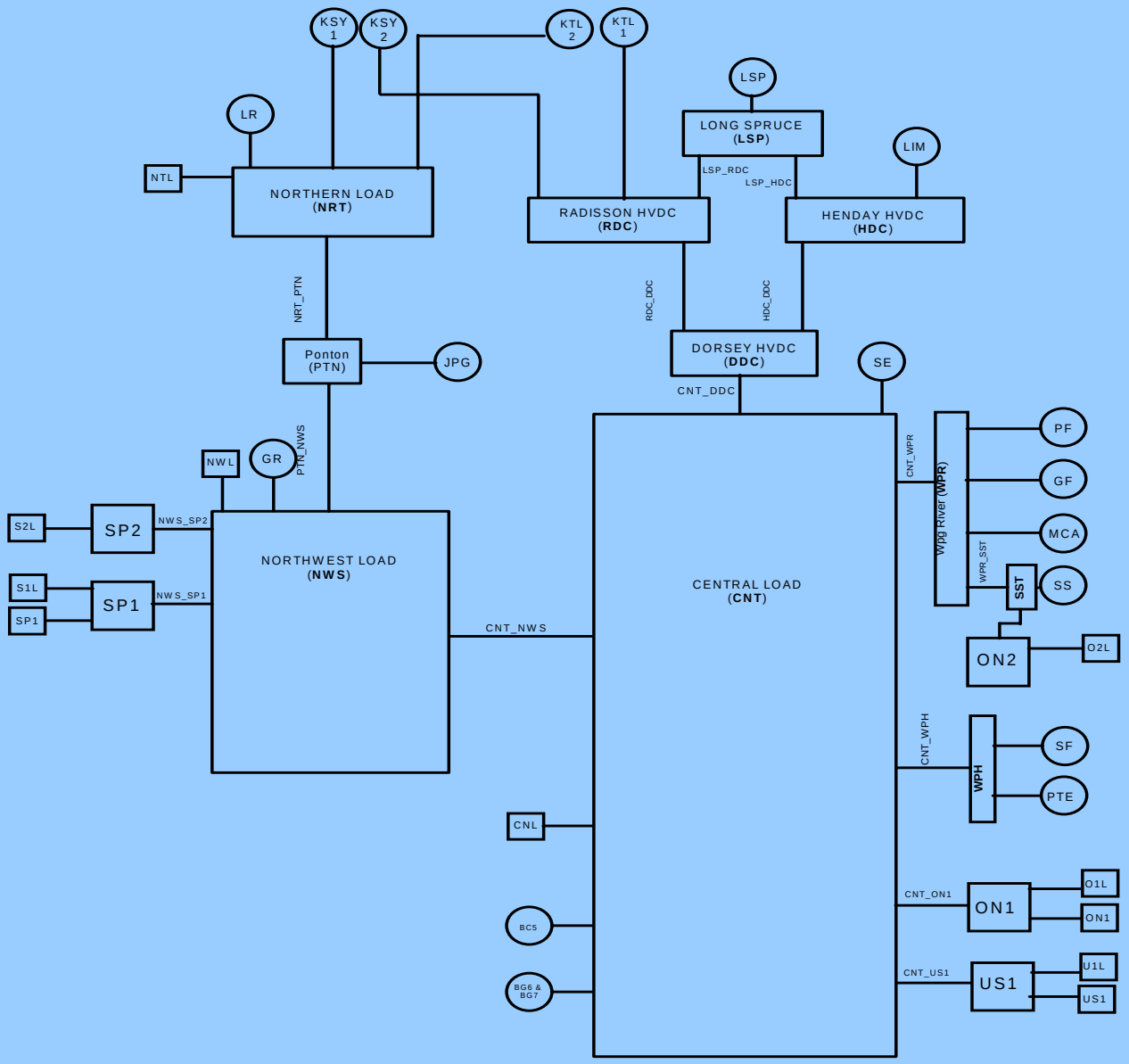
Rock Island Schematic





Water power has been the main source of electric generation in Manitoba since 1906. As of March 31, 1985, the province's developed hydraulic capacity amounted to 3 644 megawatts (MW).

Beyond 1985, further hydraulic development is possible at a number of Manitoba sites — Nelson, Burntwood and Churchill Rivers — promising another 6 270 MW of additional generating capacity.


KSY 1
KSY 2
KTL 2
KTL 1
LSP
LR
LONG SPRUCE (LSP)
LIM
NTL
NORTHERN LOAD (NRT)
LSP_RDC
LSP_HDC
RADISSON HVDC (RDC)
HENDAY HVDC (HDC)
NRT_PTN
RDC_DDC
HDC_DDC
Ponton (PTN)
JPG
DORSEY HVDC (DDC)
SE
CNT_DDC
PTN_NWS
NWL
GR
CNT_WPR
Wpg River (WPR)
PF
GF
MCA
S2L
SP2
NWS_SP2
NORTHWEST LOAD (NWS)
CENTRAL LOAD (CNT)
WPR_SST
SST
SS
S1L
SP1
NWS_SP1
CNT_NWS
ON2
O2L
CNT_WPH
WPH
SF
PTE
CNL
CNT_ON1
ON1
O1L
BC5
CNT_US1
US1
U1L
BG6 & BG7

Considerations

- Maximize Portfolio Revenues
- Detailed Representation of Physical system and operational constraints, including availability
- Within-plant dispatch (Unit Operations)
- Hydro Detail:
  - Headpond and reservoir utilization
  - Inflow anticipation
  - Channel lag and route
- Market Price forecasts
- Transaction opportunities
  - Open Market
  - Bilateral Transactions
- Ancillary services as Constraint
- HV transmission constraints
- Integration with “renewables” especially wind

Load Forecast Plot

Load Vista

File Edit Definition Hourly Minute TableCharter Window Help

System Load Forecast

Case ID: Direct Load Cas

Bus Bar: Demo Bulk Load

View — Year: 1998 Week 01-26 to 02-01 5 Set

Action — Seed

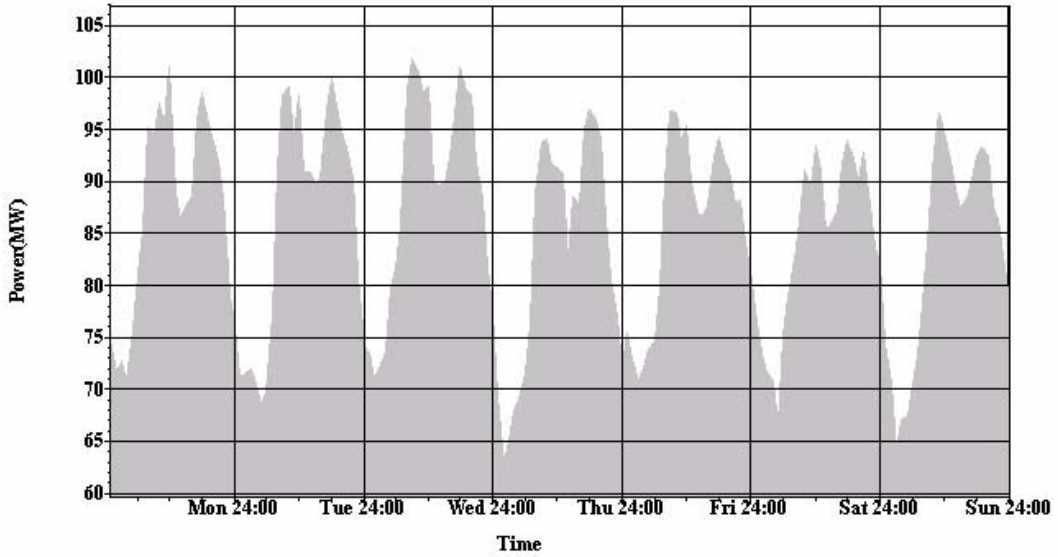
Load Uncertainty: 0.0000

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
01:00	74.71						
02:00	71.60						
03:00	72.67						
04:00	70.67						
05:00	75.69						
06:00	81.09						
07:00	85.39						
08:00	95.22						
09:00	94.50						
10:00	97.57						
11:00	95.56						
12:00	101.06						
13:00	88.78						
14:00	86.34						
15:00	87.61						
16:00	88.58						
17:00	95.99						
18:00	98.52						
19:00	96.24						
20:00	93.75						
21:00	91.99						
22:00	88.37						
23:00	79.12						
24:00	76.06						

Chart - System Load Forecast

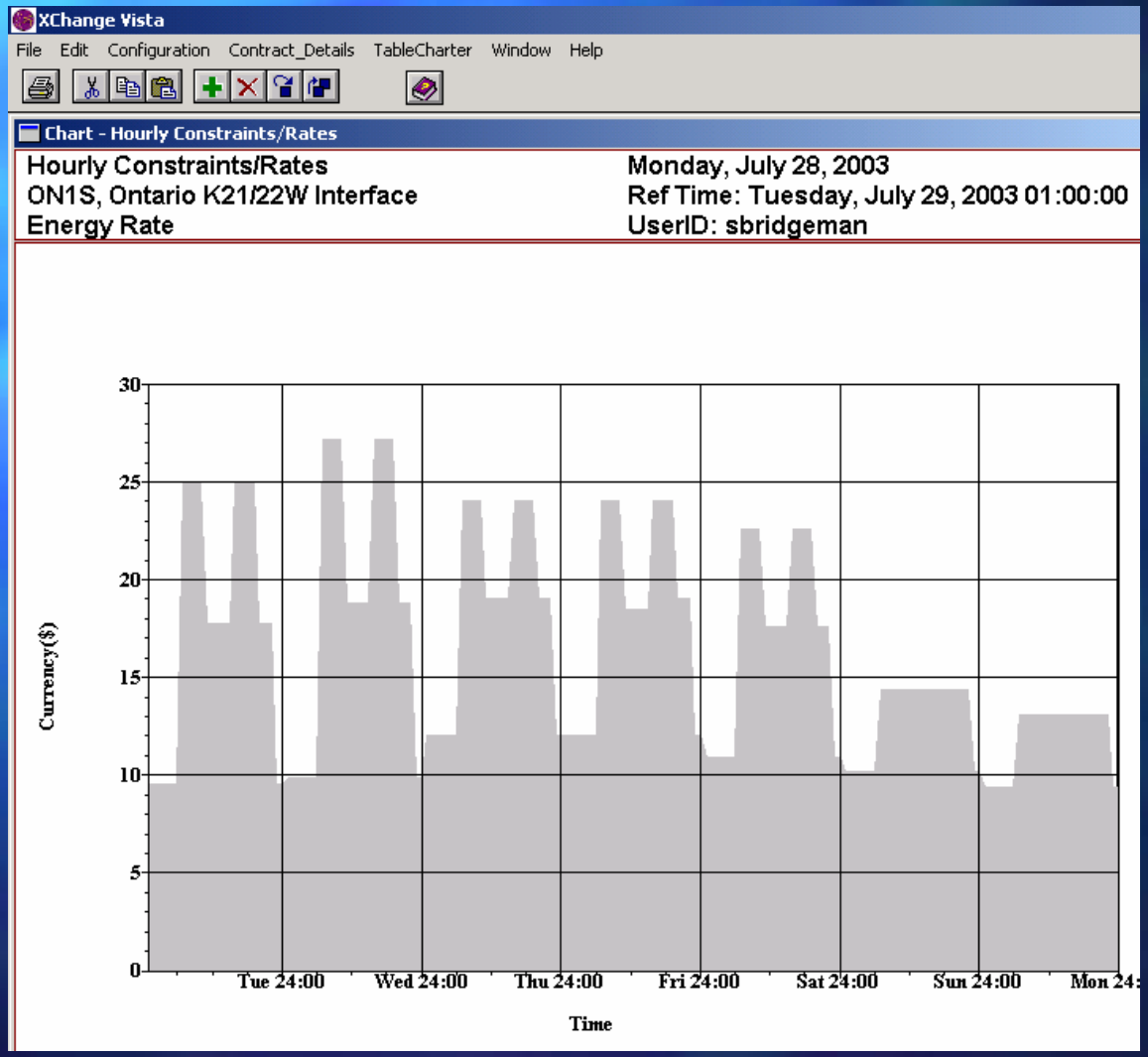
System Load Forecast
Case : Direct Load Case Bus : Demo Bulk Load Bus

Wednesday, February 20, 2002
Ref Time: Monday, January 26, 1998 01:00:00
UserID: sbridgeman

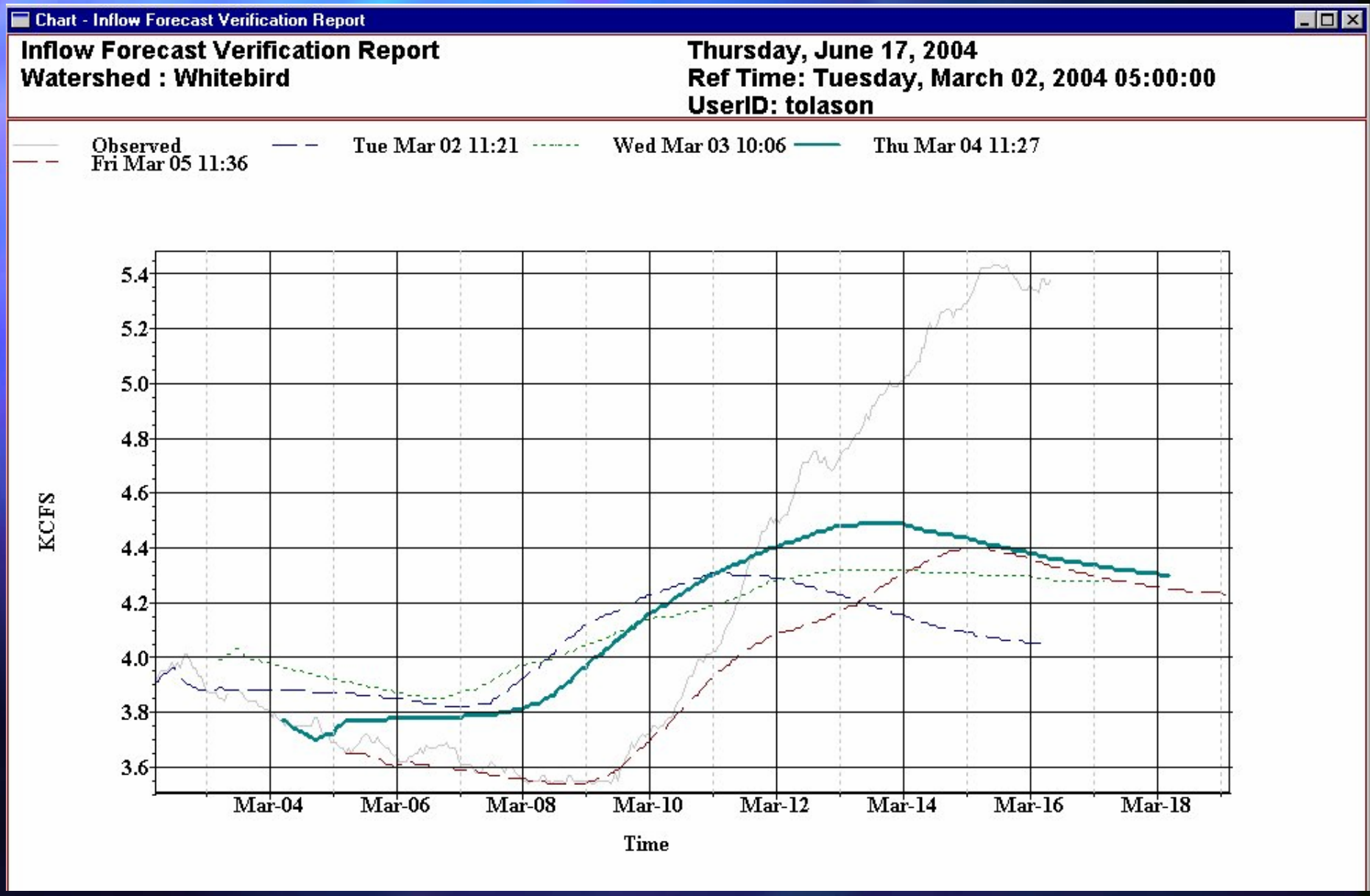


Start | Microsoft Power... | Vista | LT Vista | Short Term Gene... | Load Vista | 3:43 AM

Typical ST Price Forecast

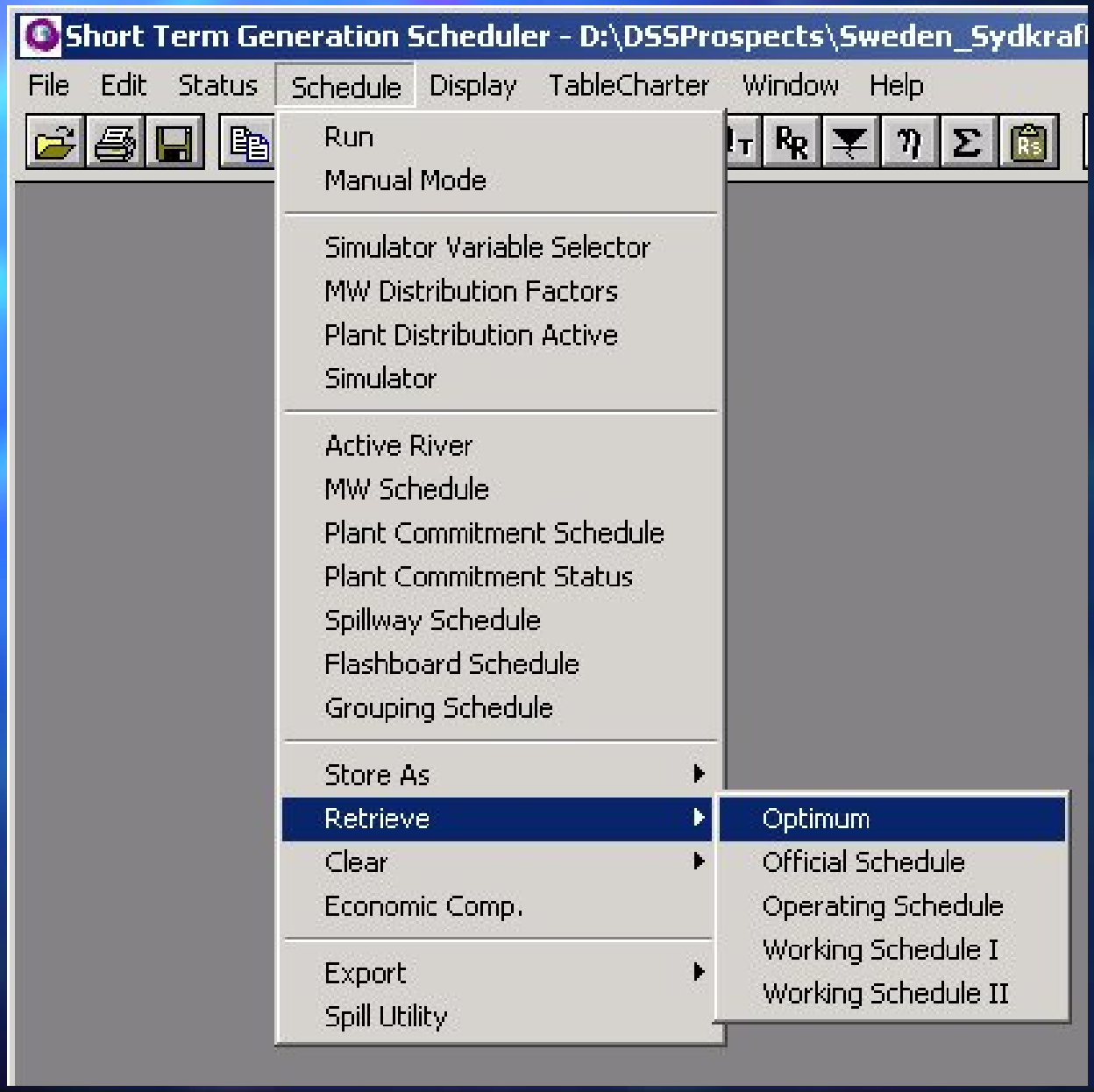


Flow Forecast Trends

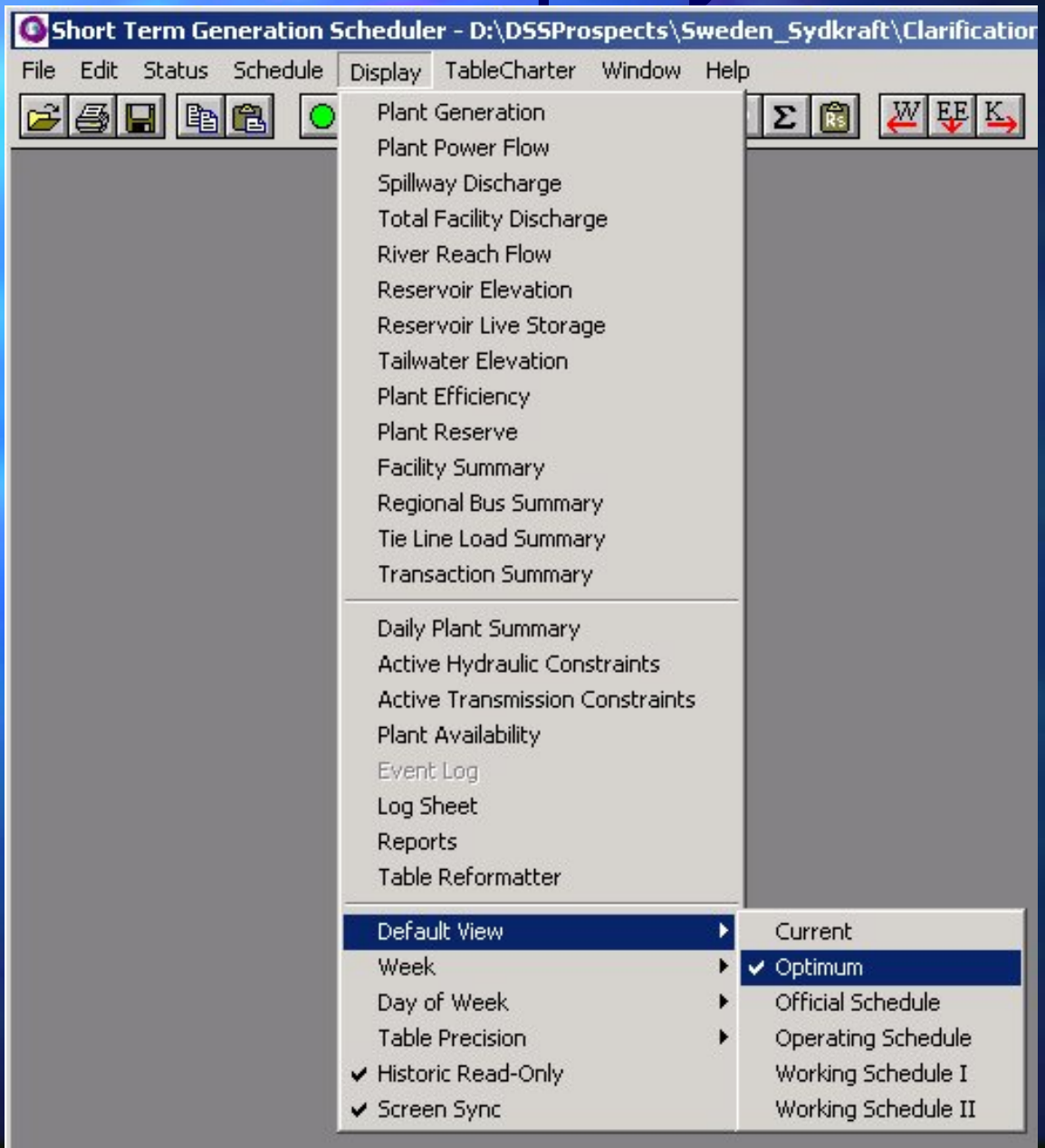


Short Term Scheduler

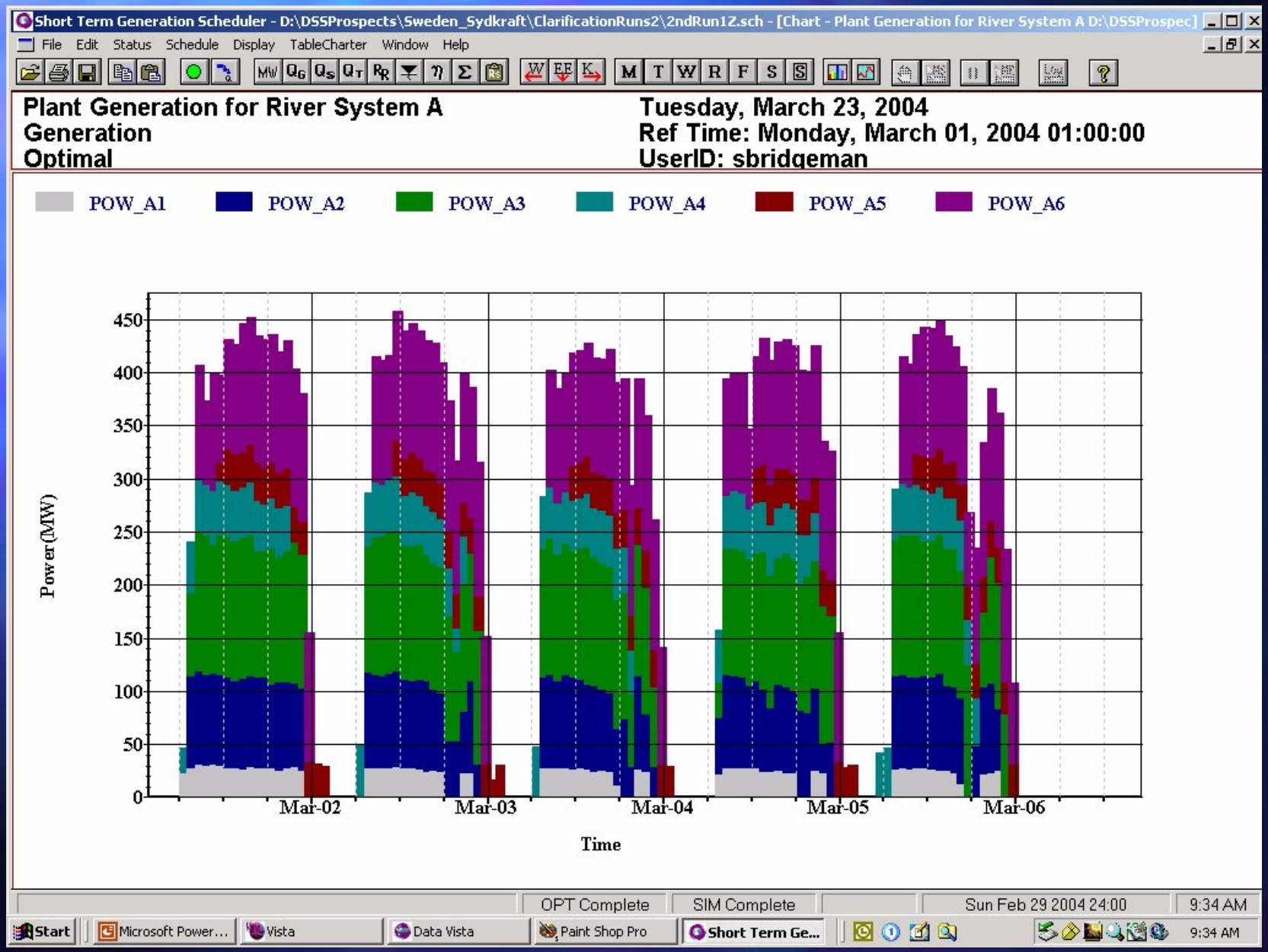
ST *Vista* Display - Schedule



ST *Vista* Display Results



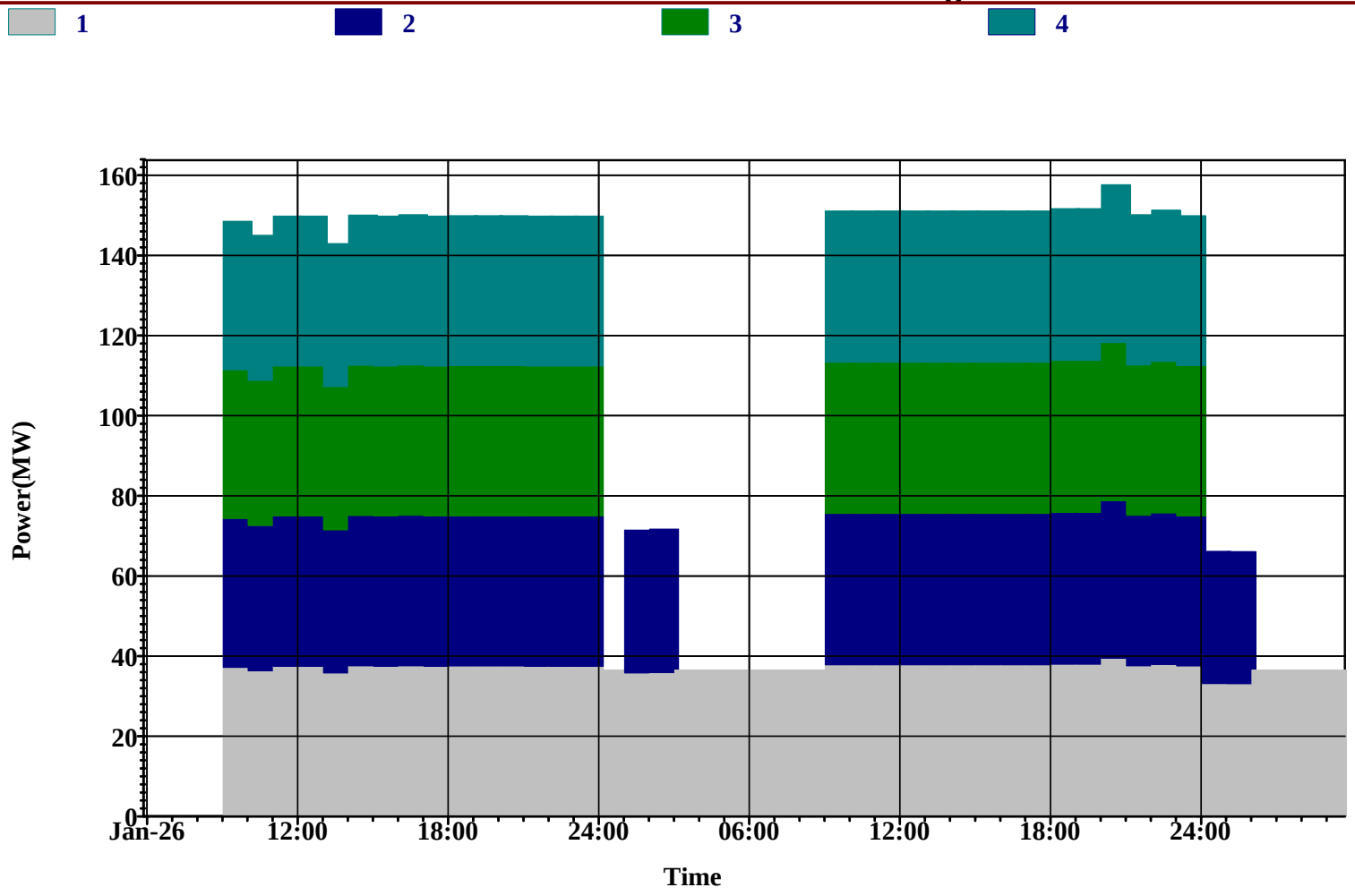
ST Generation Plot



ST Unit Schedule

Unit Generation for Cola River, Griddle Station Generation

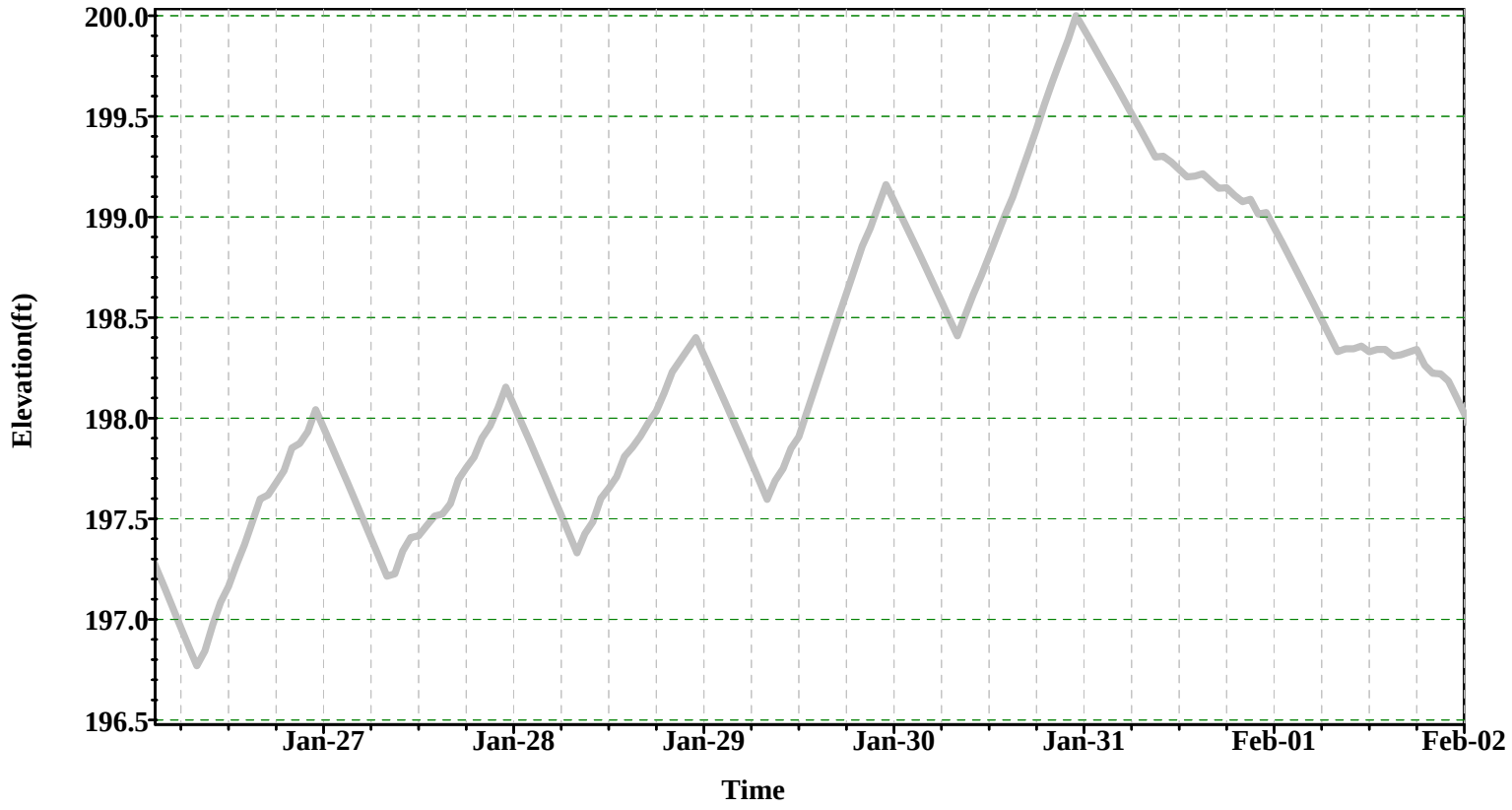
Wednesday, February 20, 2002
Ref Time: Monday, January 26, 1998 02:00:00
UserID: sbridgeman



ST Water Level Plot

Reservoir Elevation for Cola River Levels for BLT Pond

Wednesday, February 20, 2002
Ref Time: Monday, January 26, 1998 02:00:00
UserID: sbridgeman



ST Schedule Results

Short Term Generation Scheduler

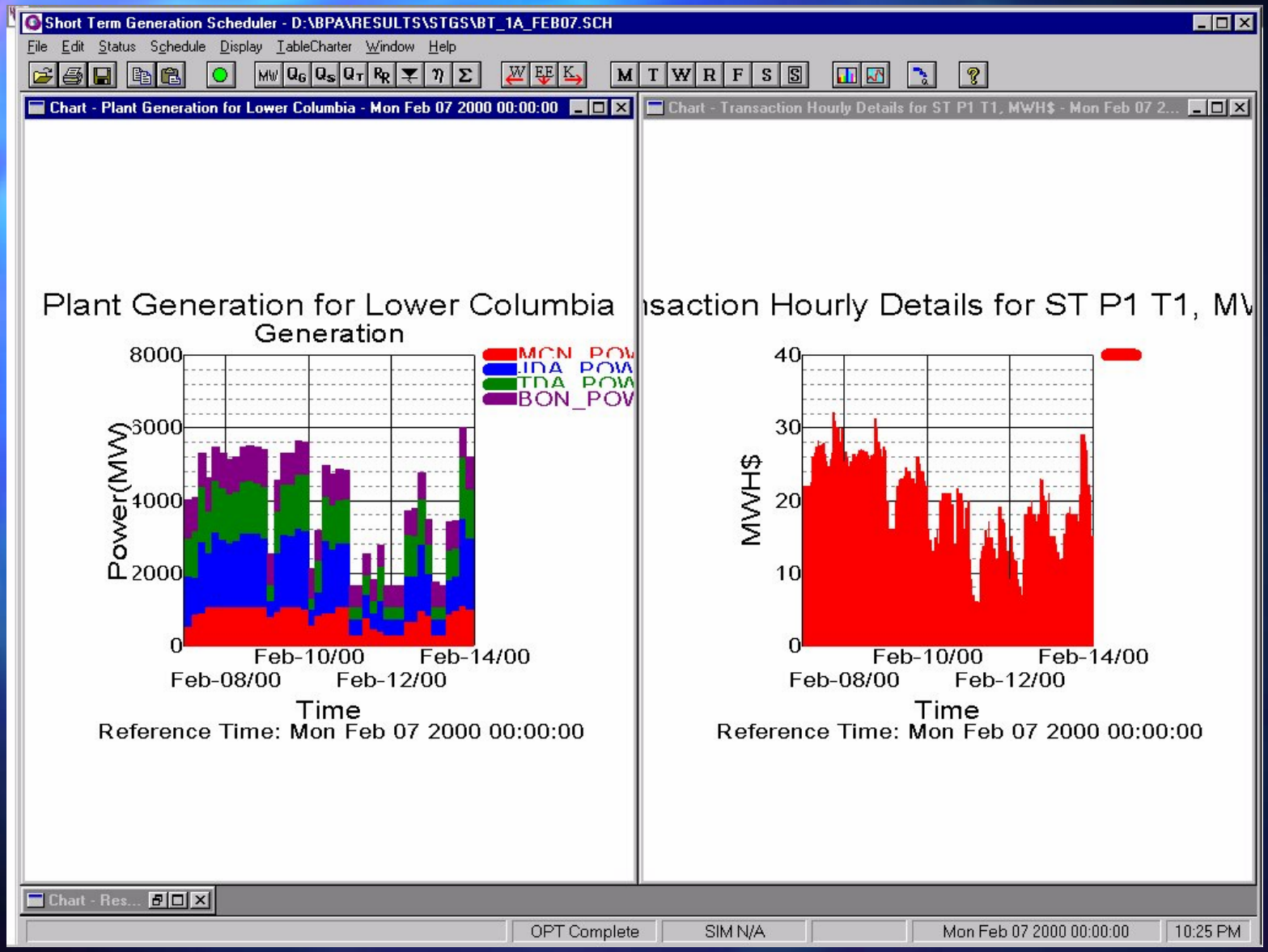
File Edit Status Schedule Display TableCharter Window Help

Plant Summary

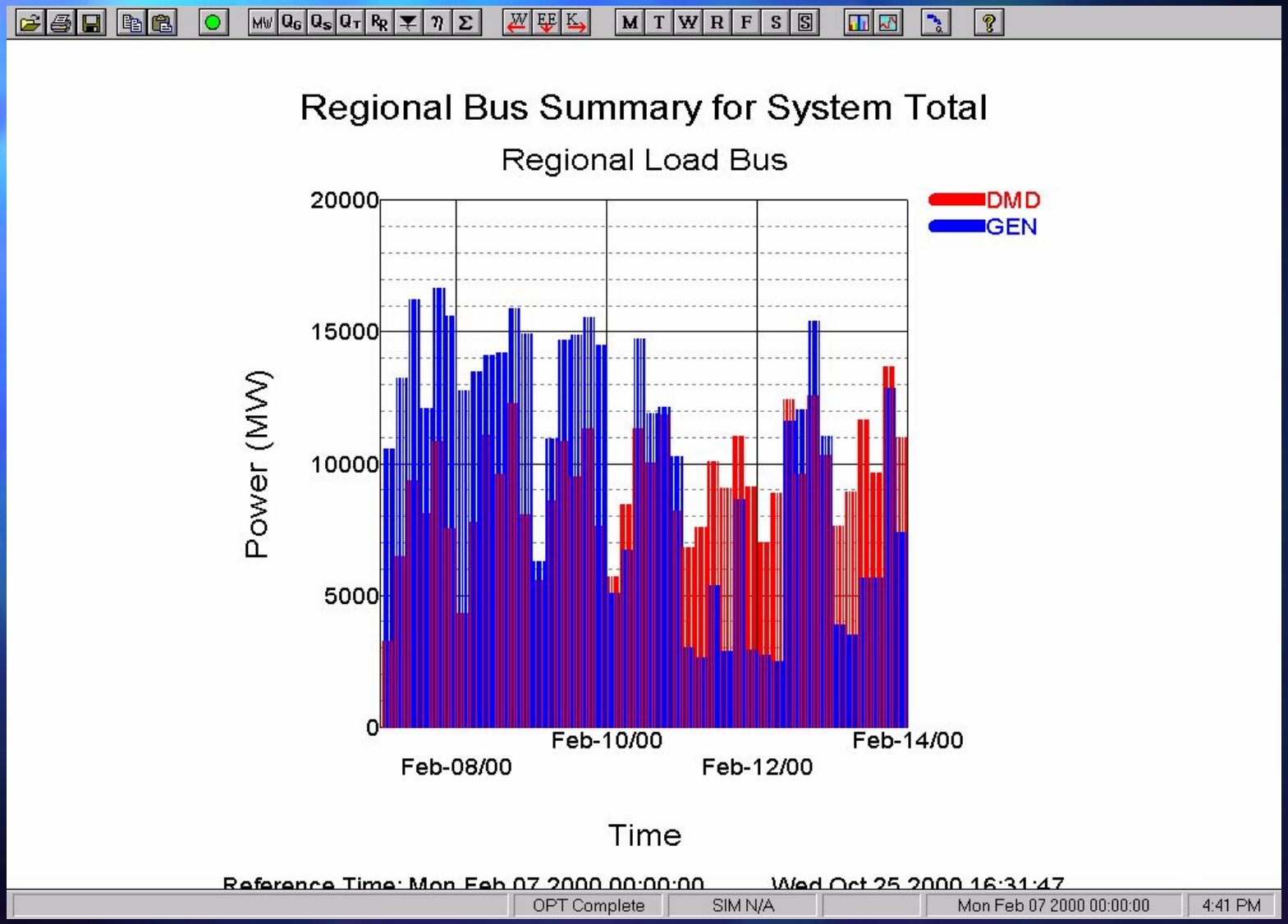
River Mersey Plant Upper Lake Falls HGP

	Elevation	TWL	Gross Head	MW	Efficiency	Power Flow	Spill	Total Flow
2 Mon 10:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 11:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 12:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 13:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 14:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 15:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 16:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 17:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 18:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 19:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 20:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 21:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 22:00	273.5	235.0	38.5	5.4	0.85	1949	0	1949
2 Mon 23:00	273.5	235.0	38.5	5.4	0.85	1950	0	1950
2 Mon 24:00	273.5	235.0	38.5	5.4	0.85	1950	0	1950
2 Tue 01:00	273.5	235.0	38.5	2.5	0.86	888	0	888
2 Tue 02:00	273.5	235.0	38.5	5.1	0.86	1818	0	1818
2 Tue 03:00	273.5	235.0	38.5	4.9	0.86	1770	0	1770
2 Tue 04:00	273.5	235.0	38.5	4.9	0.86	1758	0	1758
2 Tue 05:00	273.5	235.0	38.5	4.8	0.86	1703	0	1703
2 Tue 06:00	273.5	235.0	38.5	4.9	0.86	1759	0	1759
2 Tue 07:00	273.5	235.0	38.5	5.2	0.85	1852	0	1852
2 Tue 08:00	273.5	235.0	38.5	5.4	0.85	1950	0	1950
2 Tue 09:00	273.5	235.0	38.5	5.4	0.85	1950	0	1950
2 Tue 10:00	273.5	235.0	38.5	5.4	0.85	1950	0	1950

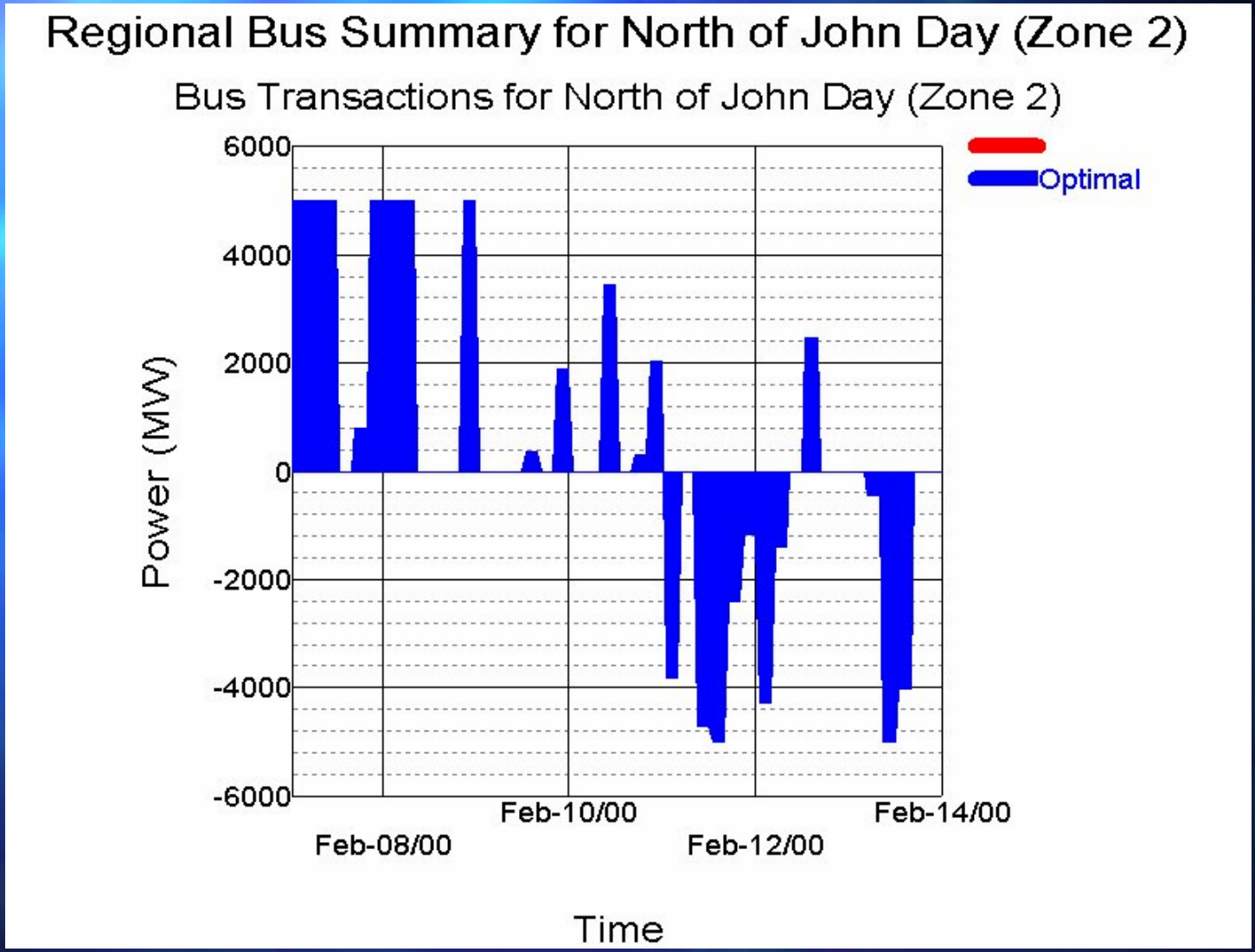
ST Schedule Results



Energy Balance



Transaction Schedule



Post-Wind Implementation

Hydro-Wind Integration

- **AUTO Vista proceeds through time one week at a time – and each week has an LT Vista run and an ST Vista run.**
- **In wind studies, wind forecasts are reasonably accurate for day 1 but quite uncertain beyond 2 or 3 days**
- **Therefore, AUTO has been enhanced to re-optimize periodically (eg) daily; each time with a new wind forecast for the next day**
- **This yields an accurate mimic of the uncertainty involved with wind generation, and the consequences of wind generation on hydro operations**

AUTO Vista - [Chart - Water Levels]

File Edit Analyse TableCharter Window Help

Water Levels

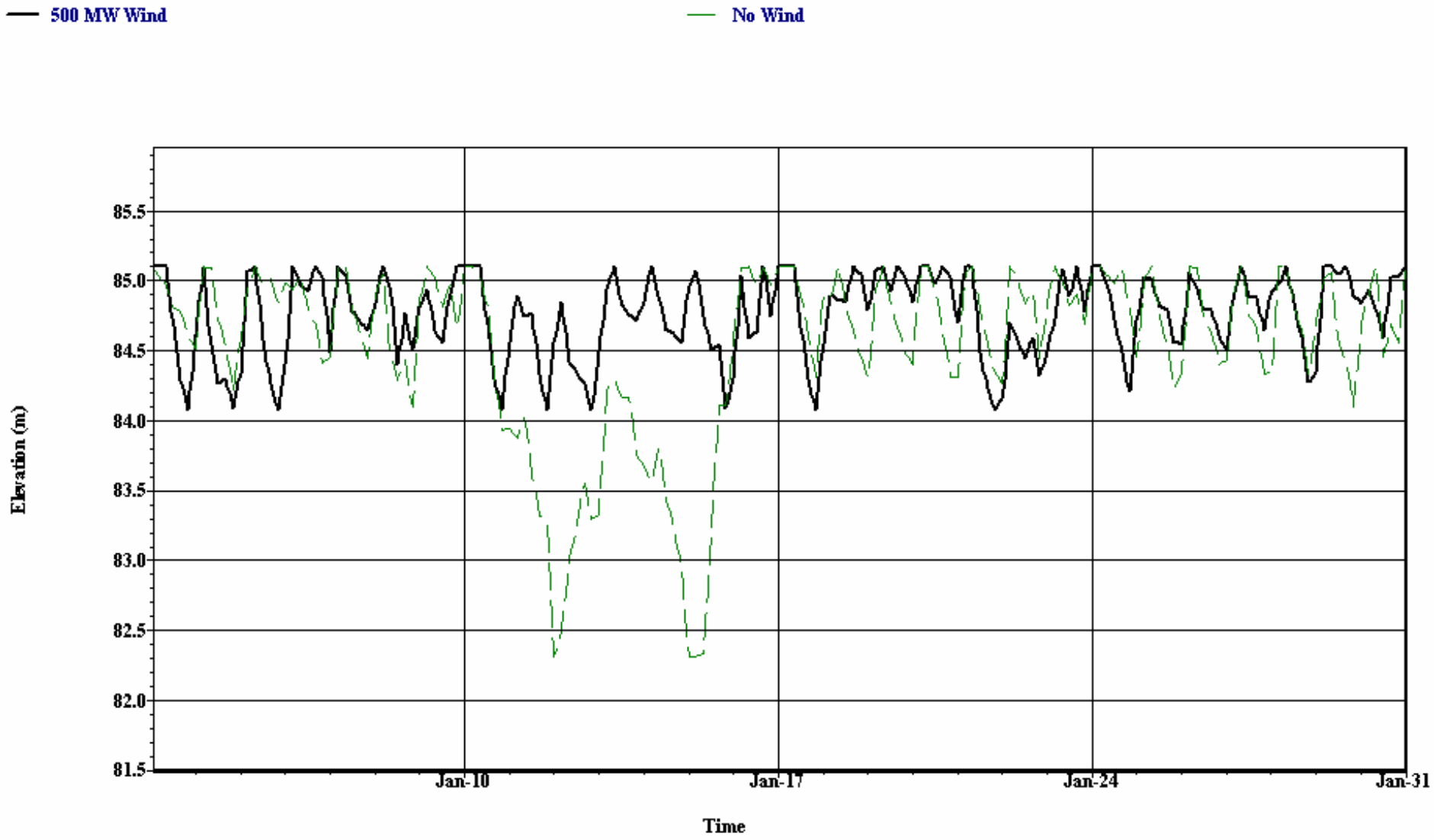
Lower Nelson

From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for resWL@LIMR(m)

Monday, November 01, 2004

Ref Time: Monday, January 03, 2011 01:00:00

Synexus Global



AUTO Vista - [Chart - Water Levels]

File Edit Analyse TableCharter Window Help

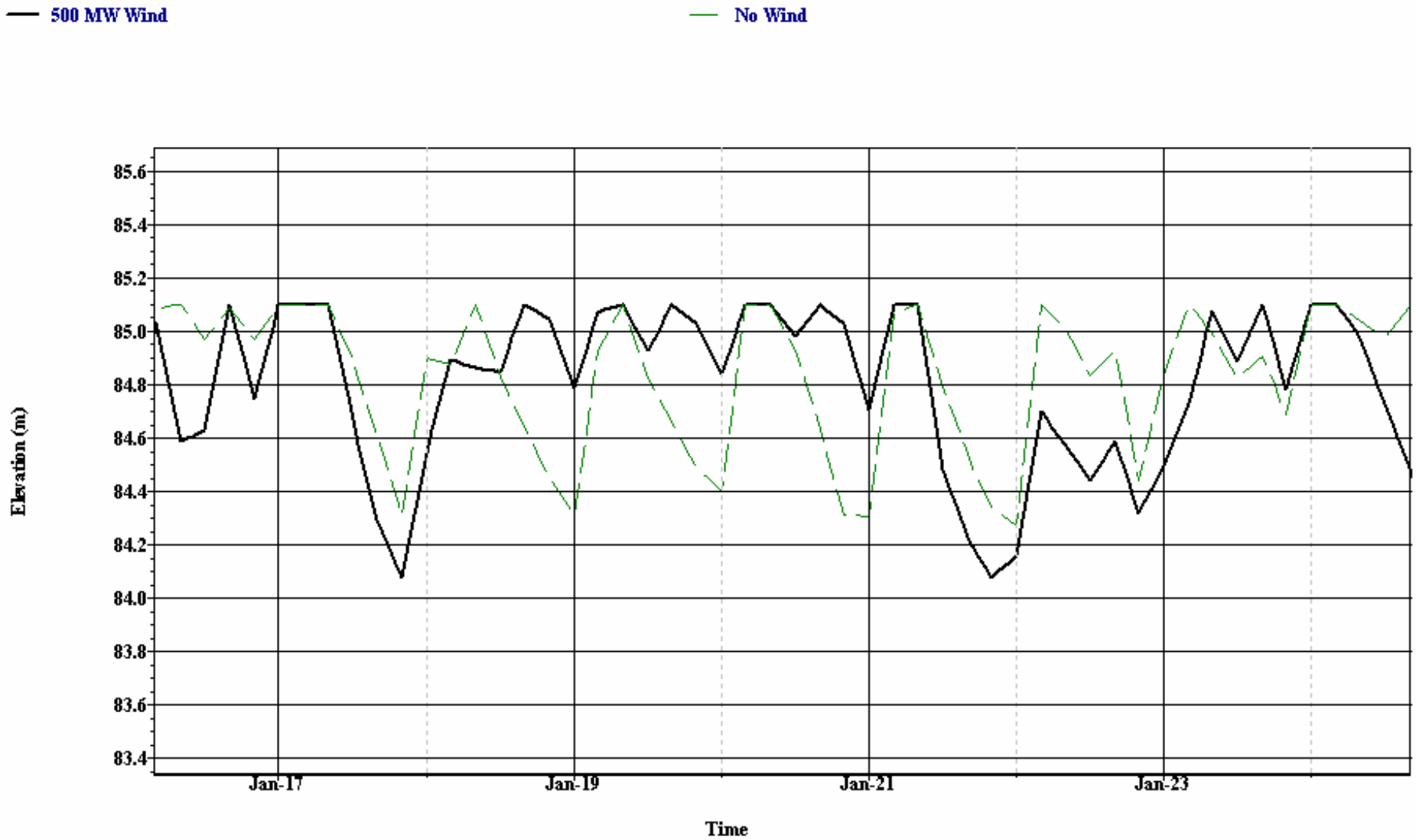
Water Levels

Monday, November 01, 2004

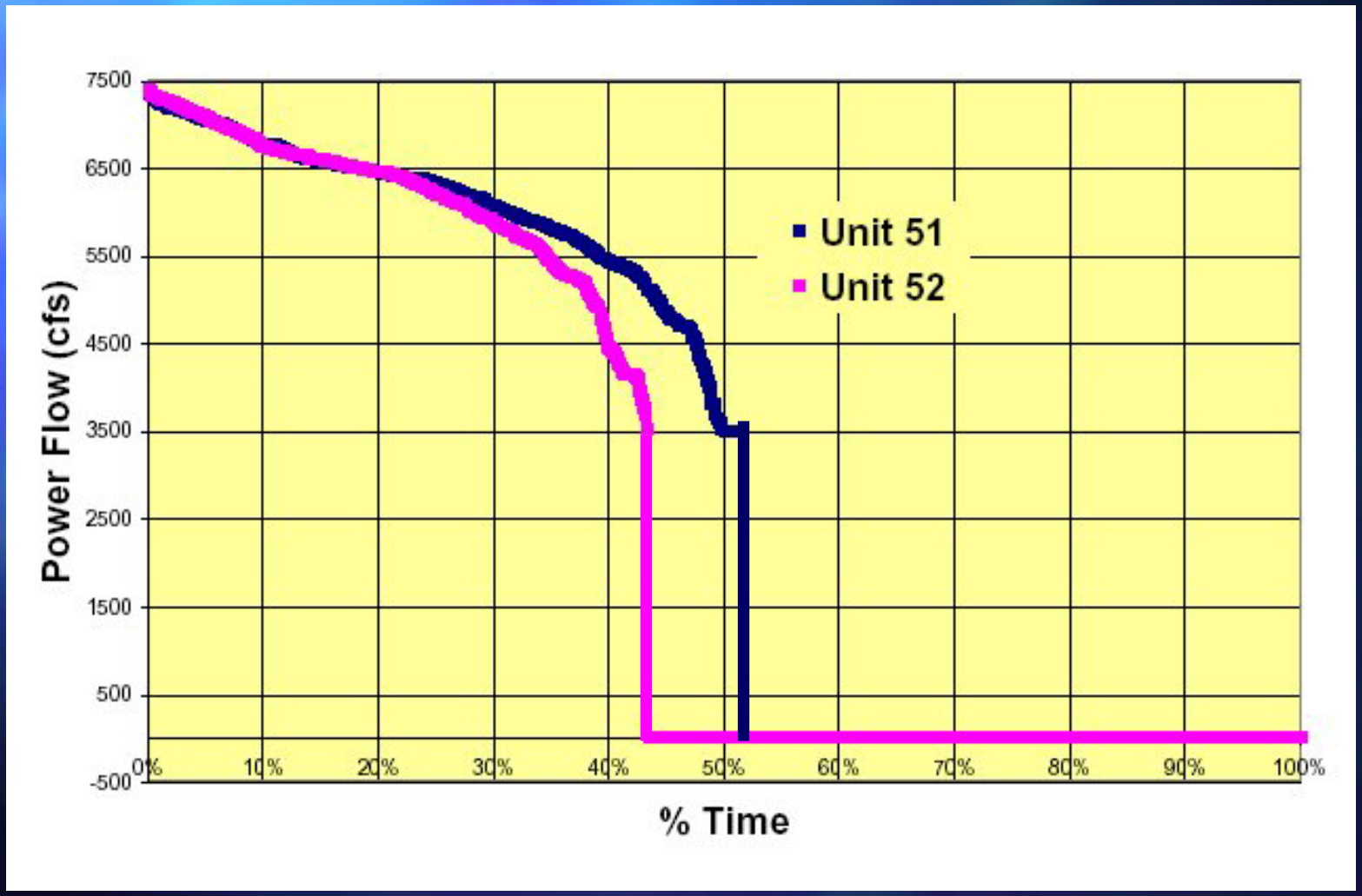
Ref Time: Monday, January 03, 2011 01:00:00

From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for resWL@LIMR(m)

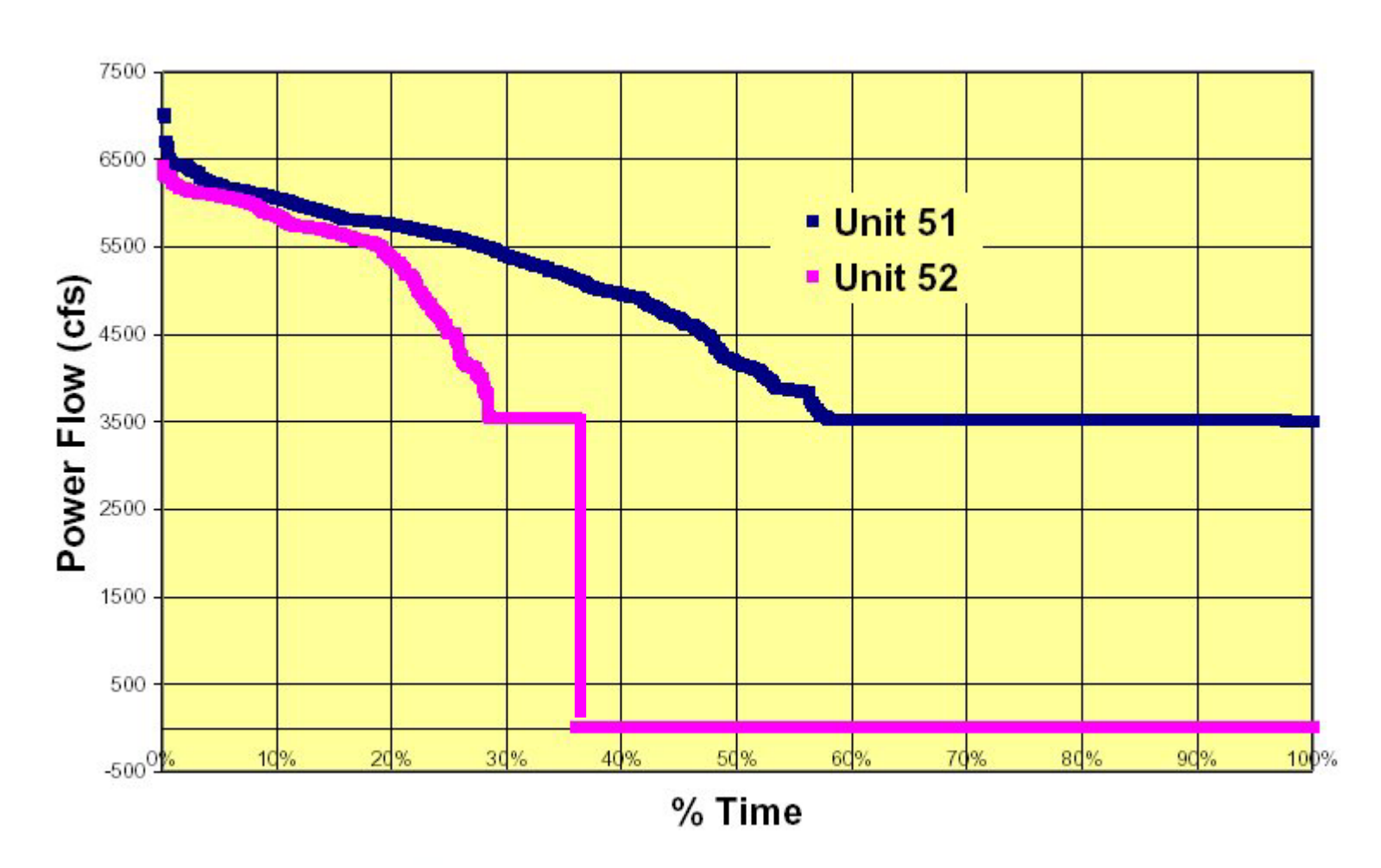
Synexus Global



Unit Duty – Before Wind



Unit Duty – After Wind



AUTO Vista - [Chart - Water Levels]

File Edit Analyse TableCharter Window Help

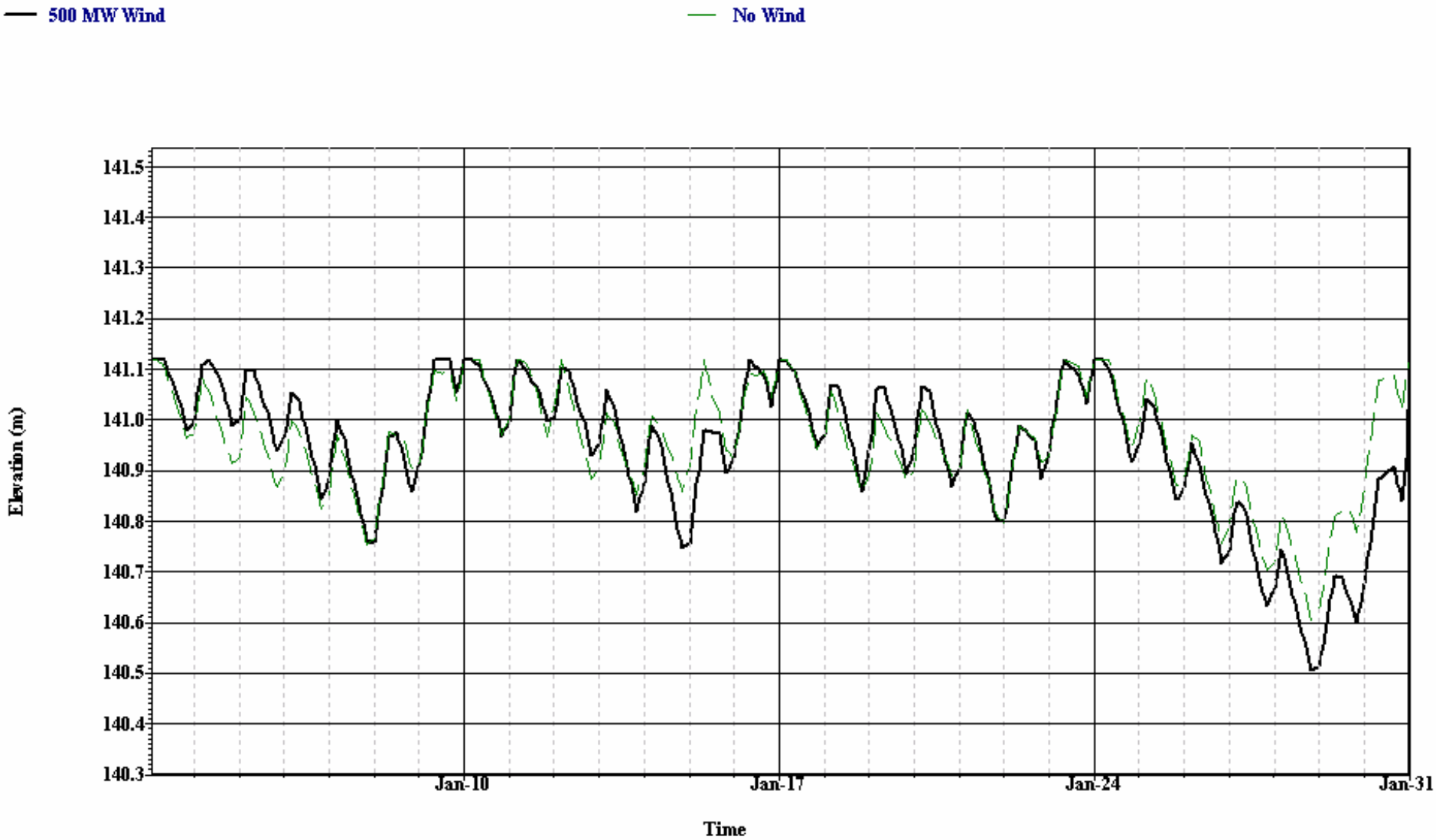
Water Levels

Monday, November 01, 2004

Ref Time: Monday, January 03, 2011 01:00:00

From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for resWL@KTLR(m)

Synexus Global



AUTO Vista - [Chart - Plant Generation]

File Edit Analyse TableCharter Window Help

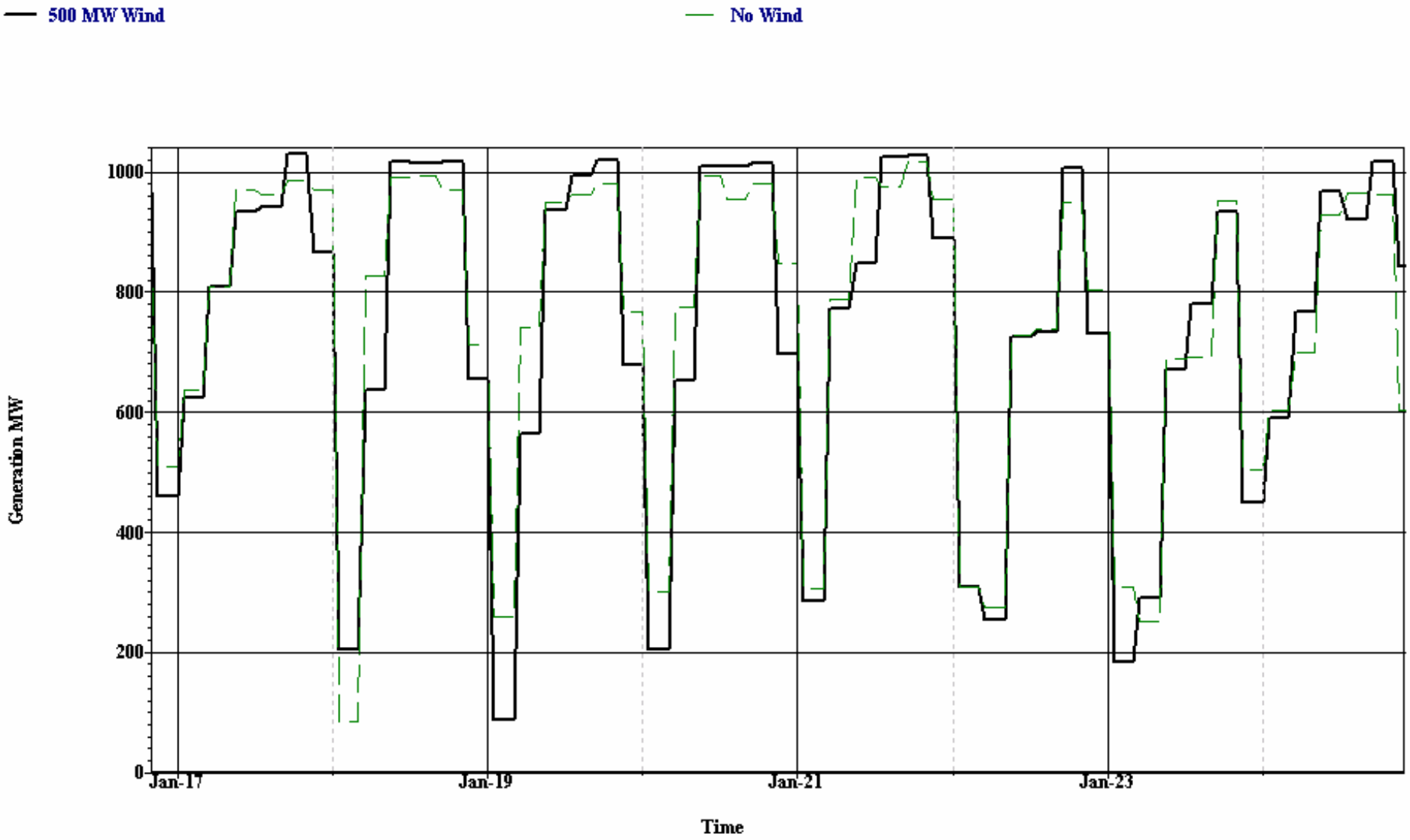
Plant Generation

Monday, November 01, 2004

Ref Time: Monday, January 03, 2011 01:00:00

From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for pltGEN@LSPP(MW)

Synexus Global



AUTO Vista - [Chart - System]

File Edit Analyse TableCharter Window Help

System

Monday, November 01, 2004

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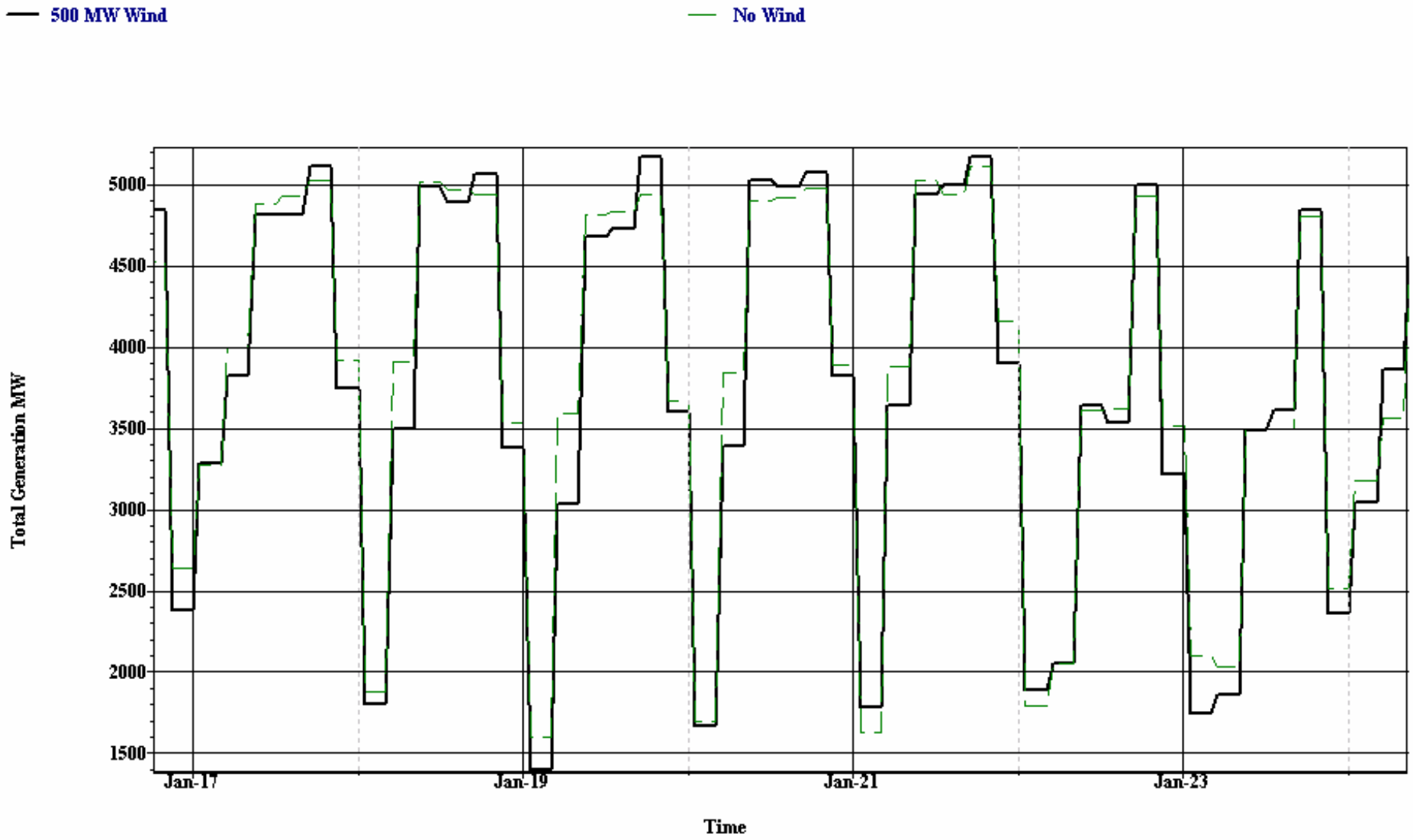
From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for sysGEN@System(MW)

Synexus Global



AUTO Vista - [Chart - System]

File Edit Analyse TableCharter Window Help

System

Monday, November 01, 2004

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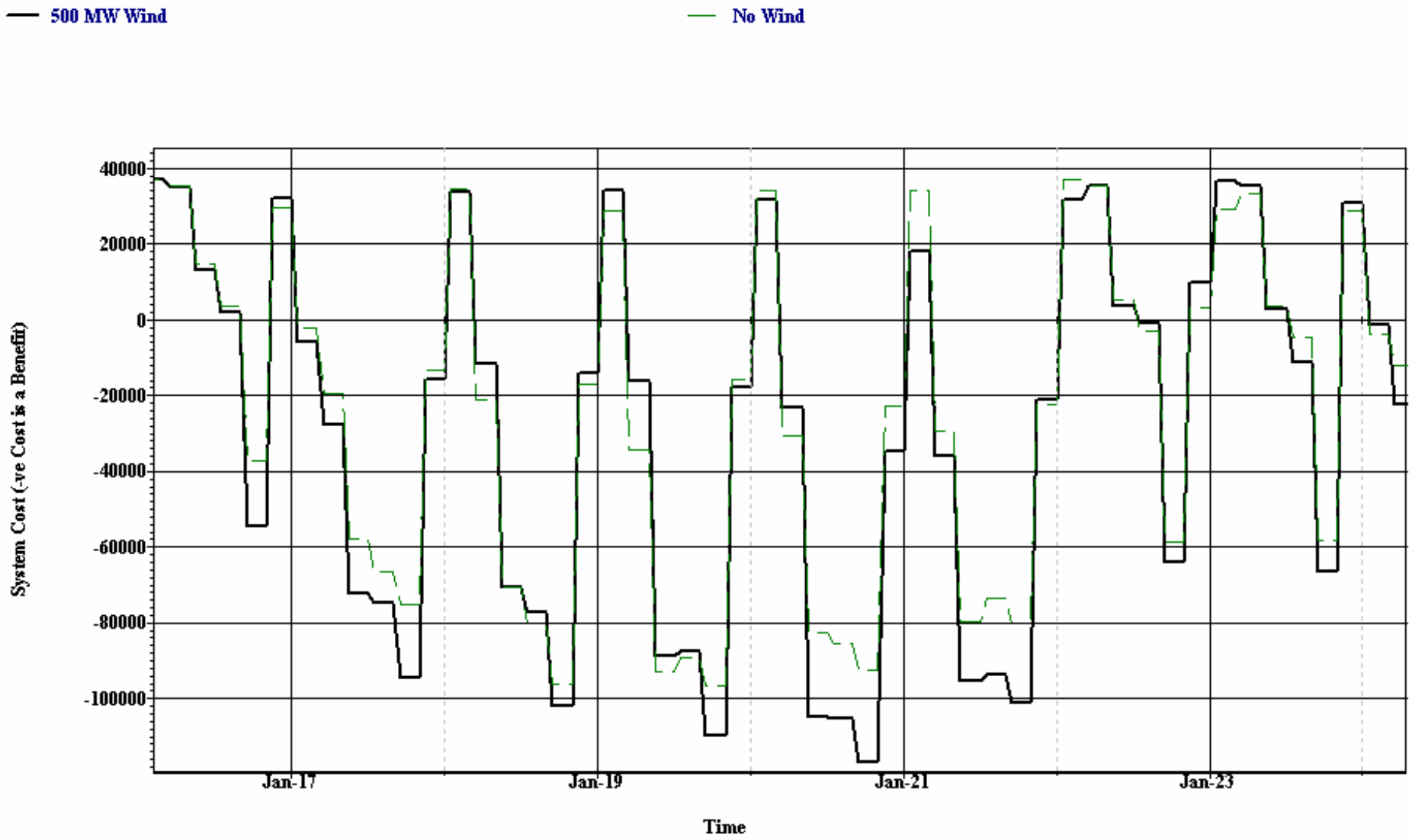
From Sat Jan 01 2011 01:00 to Sun Jan 01 2012 01:00 for sysCOST@System($)

Synexus Global



Vista
Decision Support System

Efficient Operation of Power and Water Resource Systems